CHAPTER 4

AIR-CONDITIONING SYSTEMS

Chapter Objective: *Upon completion of this chapter, you will have a working knowledge of the operating principles and components of air-conditioning.*

AMEs maintain the air-conditioning and pressurization systems of naval aircraft. These systems provide heating and cooling of the cabin and, at altitude, the pressurization required for breathing. As an AME, you will be assisting aircrews and troubleshooting discrepancies. A good knowledge of the systems is necessary to perform effectively. This chapter uses the S-3 environmental control system as the basis for discussion. To simplify matters, we have divided the system into two subsystems: bleed air and air-conditioning.

BLEED-AIR SYSTEM

Learning Objective: *Identify the operating principles and components of a bleed-air system.*

The bleed-air system is the air source for the environmental control system (ECS) and for deicing functions. There are three sources of bleed air available. The primary source is the compressor sections of the two aircraft engines. Secondary sources are from the auxiliary power unit (APU) and from an external air supply such as support equipment (SE).

SYSTEM OPERATION

As previously stated, the source of air for the bleed-air system may be from the aircraft engines, the APU, or SE. Operation of the system using each of these sources is presented in the following paragraphs. Frequent referral to the bleed-air system schematic (fig. 4-1) will aid you in understanding the material.

Engine Bleed Air

The engine bleed air is extracted from the 10th- and 14th-compression stages of each engine. The low-stage bleed-air check valve supplies the 10th-stage air, which is the primary source for operation of the ECS. When 10th-stage air is insufficient to meet ECS demands, 14th-stage air is supplied through the high-stage, bleed-air regulator valve.

One bleed-air shutoff valve is installed in each engine pylon downstream of the 10th- and 14th-stage engine-compressor bleed ports. The bleed-air shutoff valves are controlled by switches on the eyebrow panel in the flight station. Lights on the instrument panel indicate the position of the bleed-air shutoff valves. The lights illuminate when the valves are closed regardless of the position of the switches. When open, the bleed-air shutoff valves allow engine compressor bleed air to flow into the bleed-air manifolds.

The bleed-air manifold distributes bleed air from both engines into the air-conditioning and pressurization systems. Two crossover duct isolation check valves prevent the possibility of an overbleed of both engines should a rupture occur in the left or right bleed-air manifold.

The check valves, located in the left and right manifolds, allow bleed air to flow in one direction

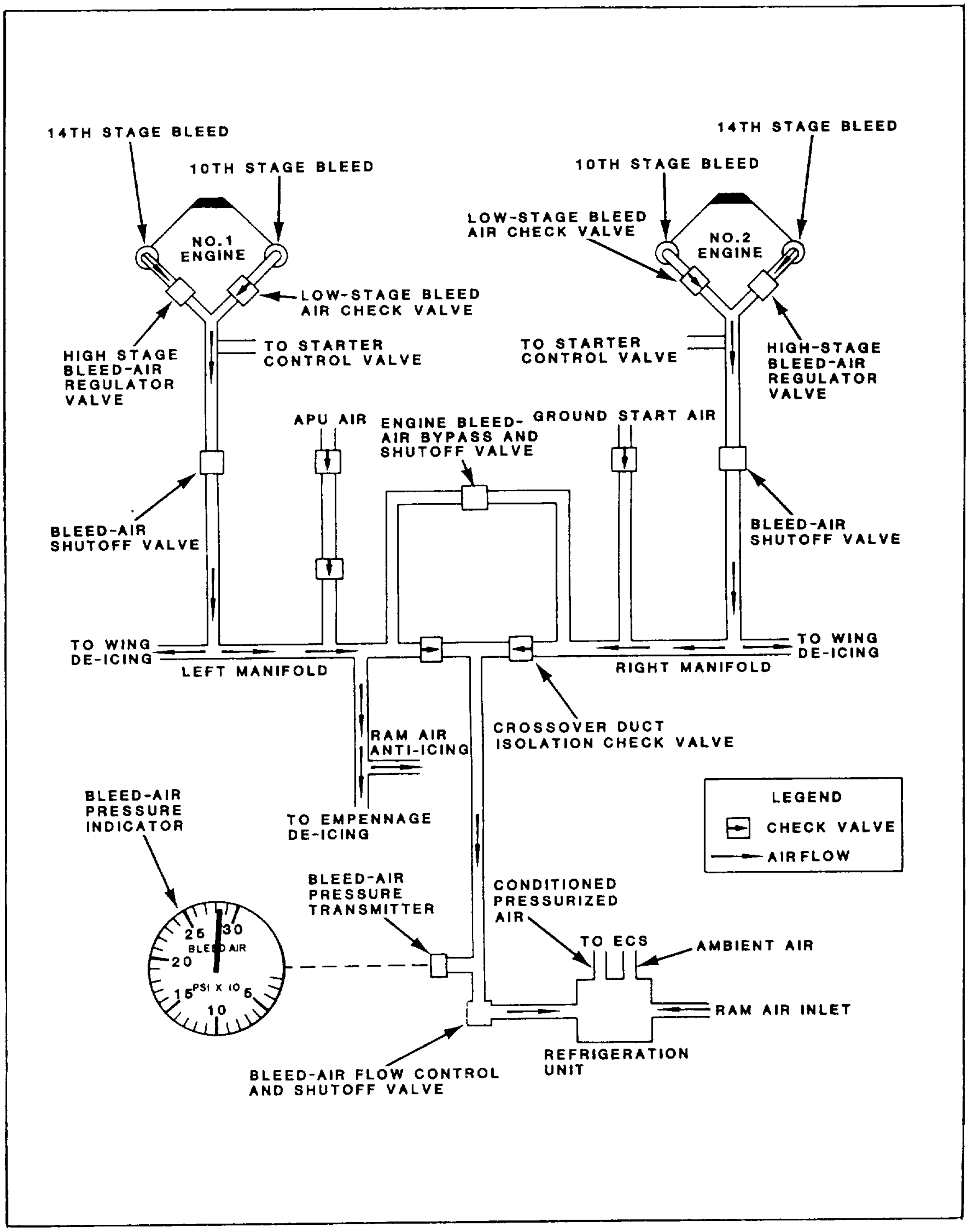

Figure 4-1.-Bleed-air system schematic.

only. If the left or right engine bleed air is secured, or if a rupture occurs in the left or right bleed-air manifold, the appropriate check valve closes. This allows the air-conditioning and pressurization subsystems to operate from the opposite bleed-air source. An open engine bleed-air bypass and shutoff valve allows bleed air to bypass the check valves and flow from the left-to-right or right-to-left manifolds. The engine bleed-air bypass and shutoff valve is open during engine starting. It is also open when operating the deicing system with one engine secured.

Bleed-air pressure is sensed by the bleed-air pressure transmitter located in the bleed-air supply duct downstream of the crossover duct isolation check valves. The pressure is displayed on the bleed-air pressure indicator on the environmental panel.

Bleed air from the left and right manifolds flows through the crossover duct isolation check valves to the bleed-air flow control and shutoff valve. The bleed-air flow control and shutoff valve is electrically controlled and pneumatically actuated to modulate the bleed-air flow to the air-conditioning and pressurization systems in response to predetermined flow schedules.

Two alternate air supply sources, APU air and ground start air, connect to the left and right bleed-air manifold. The APU air duct supplies bleed air through two check valves to the left manifold. The ground start duct supplies high-pressure air through a check valve to the right manifold. These alternate air supply sources are used primarily for starting engines and for ground operation of the air-conditioning system.

APU Bleed Air

Bleed air flows from the APU compressor through two one-way check valves in the APU duct to the left one-way check valve in the cross-breed manifold. Bleed air is also supplied to the bleed-air shutoff valve, the left side of the engine bleed-air bypass and shutoff valve, empennage deice valve, the left wing deice valve, and the ram air anti-icing valve. With the bleed-air switch in the ON position, the left bleed-air shutoff valve is opened. In the open position, bleed air is supplied to the left engine starter control valve. To provide bleed air to the right side of the cross-breed manifold, the engine bleed-air bypass and shutoff valve is opened to allow bleed air to the right bleed-air shutoff valve and to the right wing deice valve. With the bleed-air engine No. 2 switch set to ON, the right bleed-air shutoff valve is opened. In the open position, bleed air is supplied to the right engine starter-control valve.

SE Ground Start Air

When support equipment is the source of air, the ground air start hose is connected to the ground start connection nipple located in the right wheel well. External high-pressure air flows through the engine starting duct check valve into the right cross-bleed manifold. Normal flow is through the right one-way check valve in the cross-breed manifold to the bleed-air flow control and shutoff valve. High-pressure air is available to the right bleed-air shutoff valve and the right wing deice valve. Opening the right bleed-air shutoff valve provides air to the right engine starter-control valve.

To provide SE air to the left cross-bleed manifold, the engine bleed-air bypass and shutoff valve is opened. When the valve is open, air flows around the cross-bleed check valves to the left bleed-air shutoff valve, the left wing deice valve, the ram air anti-icing valve, and the empennage deicing valve. To provide air to the left engine starter-control valve, open the left bleed-air shutoff valve.

SYSTEM COMPONENTS

Now that you are familiar with the operation of the system as a whole, let's look at its components and their operation. Knowledge of the individual components makes troubleshooting easier and faster. To aid you in locating parts of the components, numbers within parenthesis ( ) are included that correlate to the numbers on the illustrations.

High-stage Bleed-Air Regulator Valve

The high-stage, bleed-air regulator valve is a normally closed, differential-pressure regulator.

(See figure 4-2.) Air from the inlet (13) passes through the filter (14), and then through the reverse-flow check valve (15). The air then enters the reference regulator (16), where it is pressure regulated (as a function of altitude) by an evacuated bellows (1). The air is then passed through a control orifice (6), a shuttle valve (8), and to the actuator section (10) of the high-stage, bleed-air regulator valve to open the butterfly (12). The pressure of the air entering the regulator sensing line (11) with the spring pressure of the actuator section of the valve modulates the valve toward the closed position, as regulated by pressure from the shuttle valve. As aircraft altitude increases, the evacuated bellows expand and cause the reference regulator to close. The ambient vent (5) decreases the pressure to the open side of the actuator section, and thereby allows the spring to close the actuator section. This action also closes the butterfly.

When the cross-bleed start solenoid (3) is energized, the reference regulator larger diaphragm (2) is vented to ambient (4). Spring pressure on the reference regulator larger

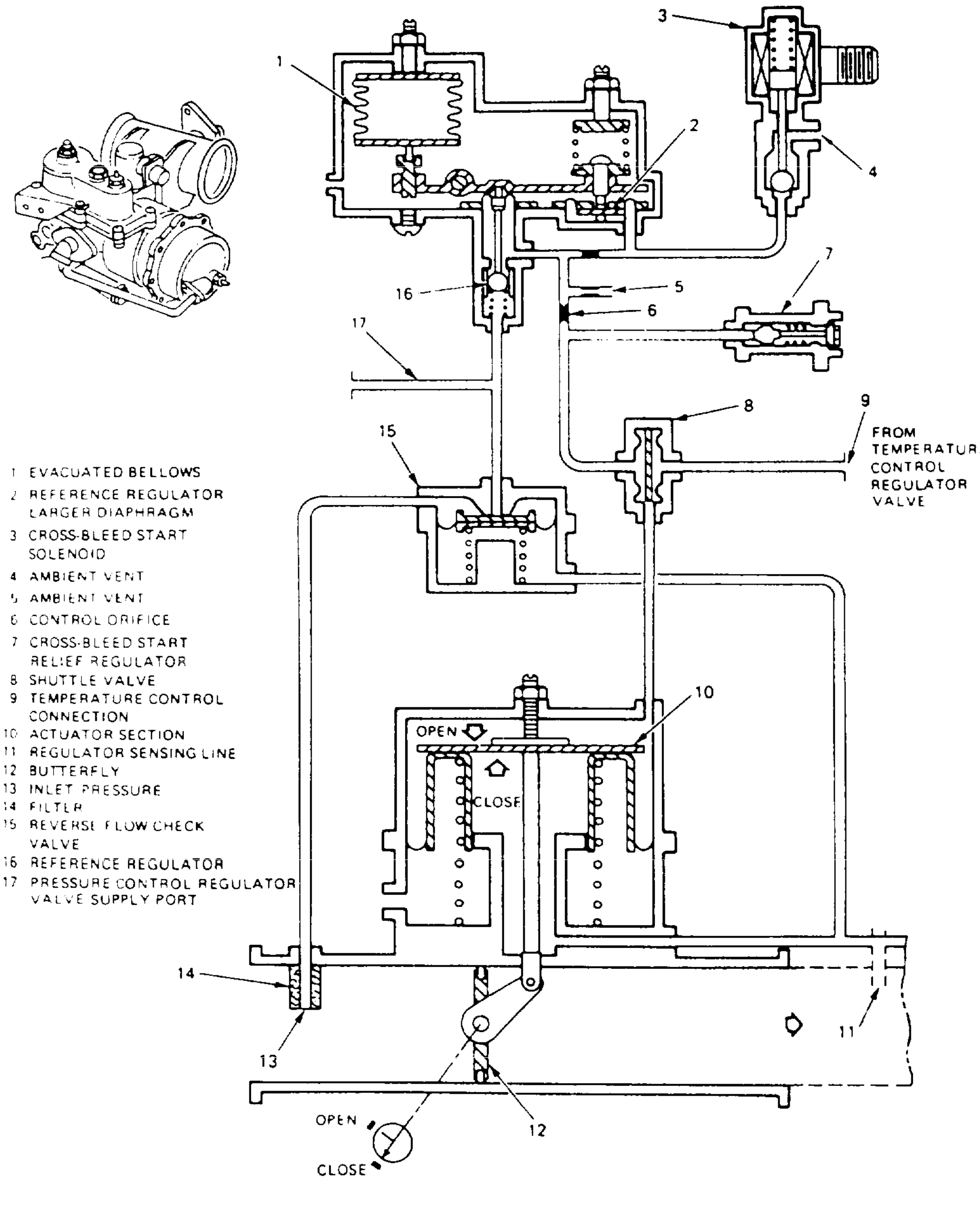

Figure 4-2.-High stage, bleed-air regulator valve schematic.

diaphragm causes the reference regulator to open. This results in pressure being passed through the control orifice, which is regulated by the cross-bleed start relief regulator (7). The pressure commands the actuator section to open with a corresponding opening of the butterfly.

During deicing operations, control pressure from the temperature control regulator valve is applied to the temperature control connection (9). This changes the shuttle valve position to allow the temperature control regulator valve pressure to open the actuator section and the butterfly. During deicing operations, pressure from the temperature control regulator valve overrides all other inputs to the shuttle valve.

Bleed-Air Shutoff Valve

The bleed-air shutoff valve is a normally closed, pneumatically operated, electrically controlled shutoff valve with provisions for automatic closure in the event of overtemperature, overpressure, or loss of electrical power (fig. 4-3.)

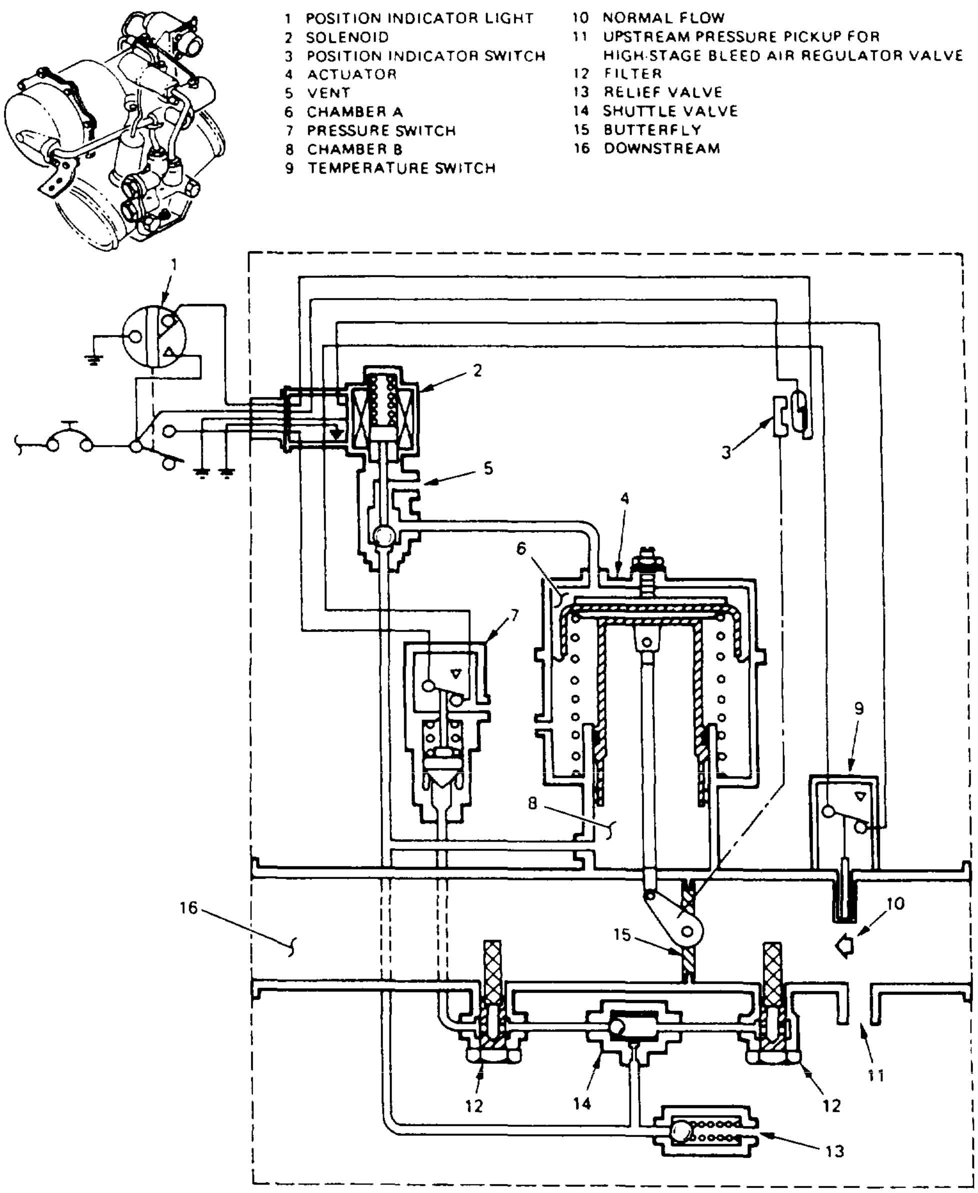

Figure 4-3.-Bleed-air shutoff valve schematic.

Inlet air pressure flows through the filters. to the shuttle valve (14), which selects the higher air pressure on each side of the butterfly (15) and routes the selected pressure to the solenoid (2) and chamber B (8). With the solenoid de-energized (as shown in figure 4-3), the opening side of the actuator (4), or chamber A (6), is vented (5) to ambient pressure through the solenoid. The resulting pressure differential between chambers A and B produces a force to keep the butterfly closed. A butterfly position indicator switch (3) controls a light (1) that indicates the butterfly is in a closed position. With the solenoid energized (opposite to the position shown in figure 4-3), air pressure is ported to chamber A, which opens the butterfly and keeps it open.

In the event of an overpressure that causes the inlet pressure downstream (16) of the butterfly to attain the preset value of the pressure switch (7), the switch actuates and de-energizes the solenoid electrical circuit to close the valve. When the inlet pressure returns to the switch reset value, the electrical circuit closes to re-establish solenoid control.

In the event of an overtemperature that causes the inlet temperature to attain the preset value of the temperature switch (9), the switch de-energizes the solenoid and closes the valve. When the temperature returns to the switch reset value, the solenoid re-establishes control.

Check Valves

Five check valves are used in the bleed-air system: two in the cross-bleed duct, two in the auxiliary power unit (APU) bleed-air duct, and one in the ground starting duct. These are 3-inch diameter, insert-type, spring-loaded closed split-flapper valves, which are designed to be inserted into, and contained by, the aircraft duct.

Low-Stage Bleed-Air Check Valve

The low-stage bleed-air check valve is installed in the engine pylon bleed-air duct on the right side of the engine. The low-stage bleed-air check valve allows bleed air from the 10th-stage engine compressor to enter the bleed-air subsystem to protect the engine when high-stage bleed air is scheduled.

The low-stage bleed-air check valve consists of a main housing and two semicircular flappers hinged on a post positioned radially through the center of the housing. The low-stage bleed-air check valve permits flow in the direction indicated by the arrow, and restricts flow in the opposite direction. The flappers are spring-loaded in the closed position.

Engine Bleed-Air Bypass and Shutoff Valve

The engine bleed-air bypass and shutoff valve, located in the cross-bleed manifold, is normally closed. It is open for engine starting and during single-engine, wing-deicing operations. (See figure 4-4.) When the solenoid (1) is energized, the shuttle valve (7) senses the higher pressure air from the right and left pressure inlets (3 and 5) and directs it through the solenoid to chamber A (6) to open the butterfly (4). When the solenoid is de-energized, air bypasses the solenoid and enters chamber B (2) to assist the spring in closing the engine bleed-air bypass and shutoff valve.

Bleed-Air Flow Control and Shutoff Valve

The bleed-air flow control and shutoff valve is a normally closed valve with two flow schedules: fixed and inlet pressure regulated. (See figure 4-5.) The valve is electropneumatically controlled and pneumatically actuated.

The venturi inlet (17) and throat pressure (18) are routed to the delta-P servo diaphragm (22). As the inlet pressure to the bleed-air flow control and shutoff valve is increased, regulated pressure routed to the actuator diaphragm (13) causes the butterfly (15) to open. When the resultant venturi delta-P reaches the predetermined value, as set by the calibration spring (12), the delta-P servo diaphragm moves. This causes the flexure beam (11) to lift off the servo valve and seat (20). This decreases pressure downstream of the control orifice (3), which closes the butterfly to a position that maintains the desired venturi delta-P. This delta-P corresponds to the desired high-flow setting when solenoid A (26) is de-energized.

When solenoid A is energized, regulated pressure acting on the high-flow low-flow reset diaphragm (7) moves the reset lever to the low-flow stop (10) and reduces the calibration spring load on the delta-P servo diaphragm. This causes the delta-P servo diaphragm to regulate the airflow at low condition. Solenoid A is operated electrically by an altitude switch (25). As the venturi inlet pressure increases, the inlet pressure compensating piston (5) moves against the reset lever (9) and modulates the air flow to a low value. The inlet pressure compensating spring preload and rate are selected to provide a prescribed schedule. When solenoid B (27) is energized, actuator pressure is vented to ambient, and the butterfly valve closes.

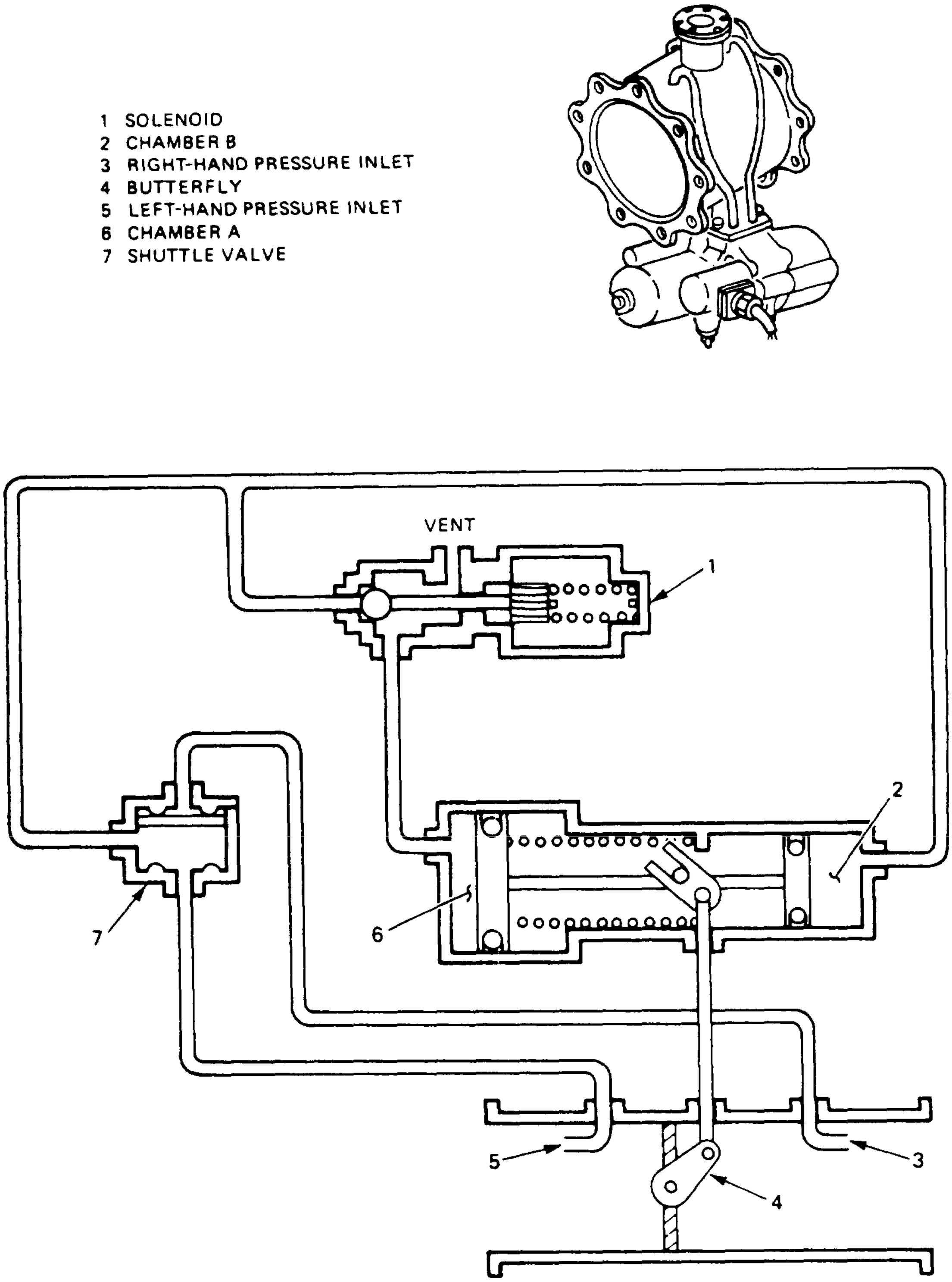

Figure 4-4.-Engine bleed-air bypass and shutoff valve.

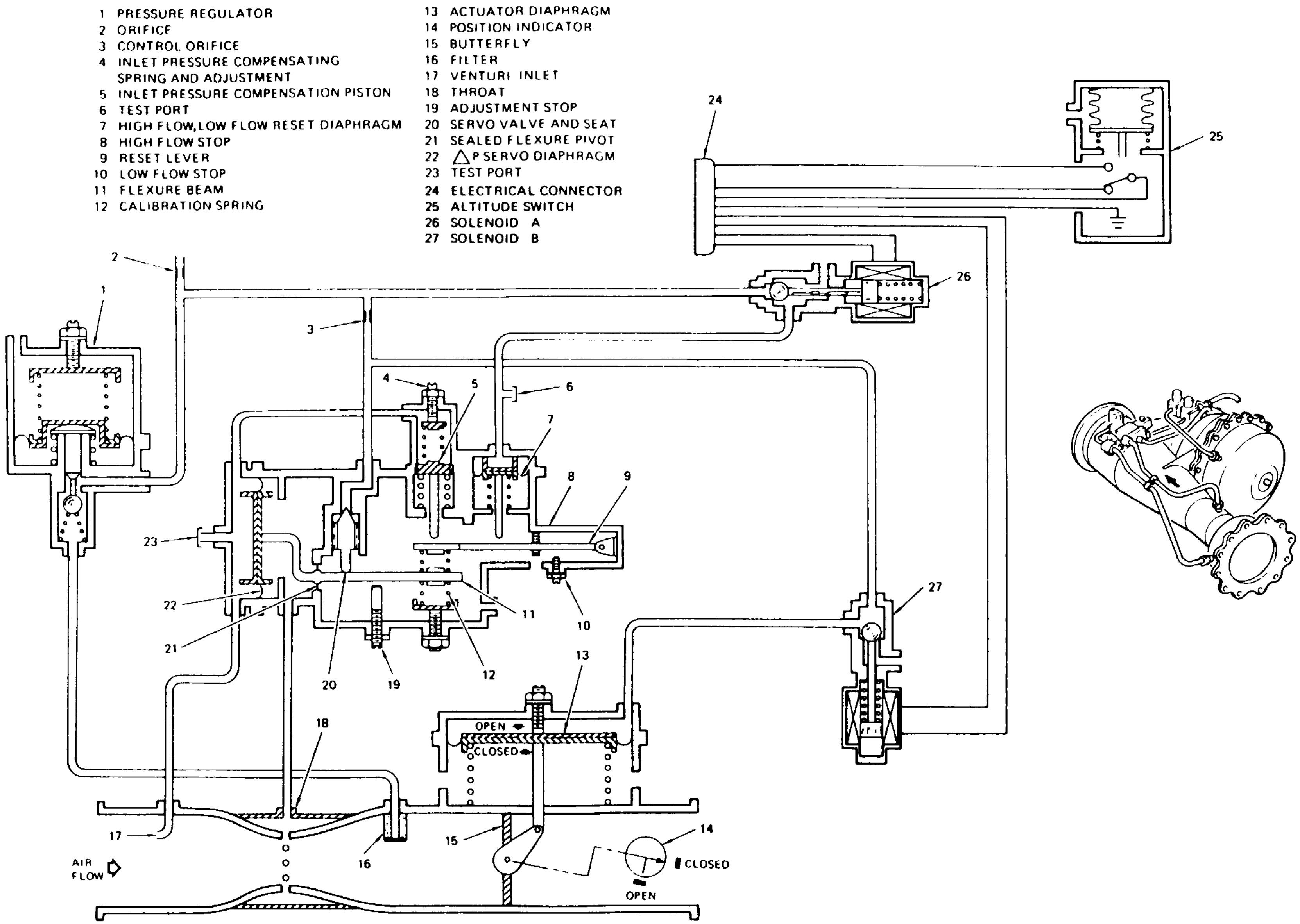

Figure 4-5.—Bleed-air flow control and shutoff valve schematic.

Bleed-Air Transmitter

The pressure transmitter senses the bleed-air pressure in the duct upstream from the bleed-air flow control and shutoff valve. The pressure transmitter transmits the pressure indication to the bleed-air pressure indicator on the environmental panel.

AIR-CONDITIONING SYSTEM

Learning Objective: *Identify the operating principles and components of an air-conditioning system.*

The air-conditioning system consists of two subsystems: refrigeration and cabin temperature control. These subsystems and their components are discussed in the following paragraphs.

REFRIGERATION SUBSYSTEM

The refrigeration subsystem, shown in figure 4-6, consists of two physically separated packages: refrigeration and cabin air/water separator. The refrigeration subsystem operates on bleed air, which is temperature and pressure regulated. Passage through the ram air-cooled heat exchanger reduces the bleed-air temperature to

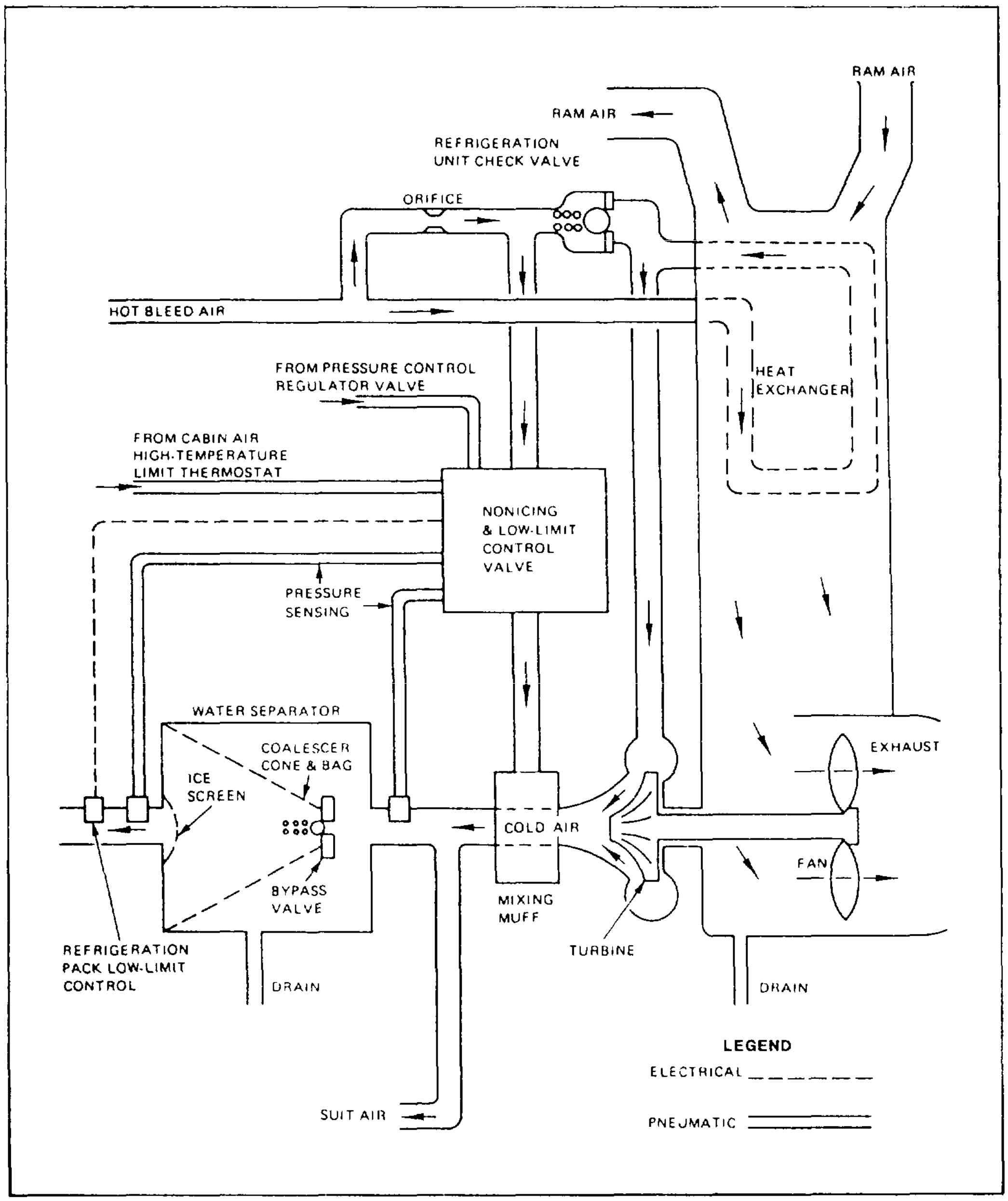

Figure 4-6.-Refrigeration subsystem schematic.

within a few degrees of ambient air temperature. Further temperature reduction results from expansion at the turbine. Condensation is removed in the water separator.

System Operation

Regulated hot bleed air from the bleed-air supply subsystem enters the refrigeration unit heat exchanger, where it is cooled to within a few degrees of ram-air temperature. The cooled high-pressure bleed air enters a radial flow turbine, where it expands to approximately cabin pressure. The power output of the expansion turbine drives an axial-flow cooling air fan. A substantial temperature drop occurs in the expansion of high-pressure air to cabin pressure (165 psi bleed-air to 15 psi cabin air), which results in air temperatures well below ram-air temperature.

Depending upon the cool air temperature and dew point, a portion of the water vapor in the air condences as small droplets. A water separator is installed downstream from the turbine discharge to remove between 50 and 70 percent of the moisture in the cooled air. If the turbine discharge air is also below 32°F, the water vapor condenses as ice crystals. Potential icing and blockage are eliminated by the nonice and low-limit control valve, the ice screen, and the mixing muff. The nonice and low-limit control valve senses any pressure drop through the ice screen. If ice accumulates, the nonice and low-limit control valve admits turbine bypass air into the mixing muff to increase air temperature above icing conditions.

Ram cooling air for the heat exchanger flows through the heat exchanger core. The turbine shaft drives the fan, which pulls the ram air through the heat exchanger and discharges it overboard through the heat exchanger exhaust duct.

Components

There are nine basic components in the refrigeration subsystem. Each of these components is discussed in the following paragraphs. The relationship of the items is shown in figure 4-6.

TURBINE AND FAN ASSEMBLY.— The turbine and fan assembly (fig. 4-7), which is mounted in the heat exchanger upper plenum (7), is a removable component of the refrigeration package. High-pressure, partially cooled bleed air drives the turbine, which is mechanically coupled to an axial flow fan. The fan is used to impel ram air through the heat exchanger and an overboard exhaust duct. Pressure reduction and final heat loss occur as a result of energy loss and expansion of bleed air as it passes through the turbine.

Wool wicks, with one end submerged in MIL-L-23699 oil, transmit lubricant to the bearings supporting the common shaft of the turbine and fan assembly. A sight gauge on the turbine housing is used to check the oil level.

Two overtemperature indicators are installed on the turbine. Each sensor probe head holds down a spring-loaded pop-up stem with an eutectic solder alloy. If the air in the passage reaches the melting point for the solder alloy, the indicator head pops up and stays exposed to alert maintenance personnel that the cooling turbine has been exposed to an excessive temperature level and needs to be replaced. The probe in the turbine inlet is set to trip at 217°±10°F, and the probe in the fan inlet will trip at 450°±10°F. Obstructions or collapse of the ram air inlet duct is the most likely cause of actuating this indicator.

HEAT EXCHANGER CORE, UPPER AND LOWER PLENUMS.— The heat exchanger lower plenum (2) contains the ducting for the ram air inlet and outlet. Cooling ram air (4) flows into the lower plenum and through the heat exchanger core (3) and out through the overboard exhaust duct (6) to the upper plenum, or to the ram air augmentation subsystem (5).

The heat exchanger upper plenum, which supports the turbine and fan assembly (1), is mounted on the opposite side of the heater core. Ram air drawn through the heater core for cooling purposes is diverted to the heat exchanger exhaust duct through the heat exchanger upper plenum. The heat exchanger core is the air-to-air heat sink, and it uses ram air to cool the bleed-air supply.

NONICING AND LOW-LIMIT CONTROL MODULATING VALVE.— The nonice and low-limit control valve maintains conditioned airflow through the water separator by adding bleed air at the mixing muff to prevent water separator

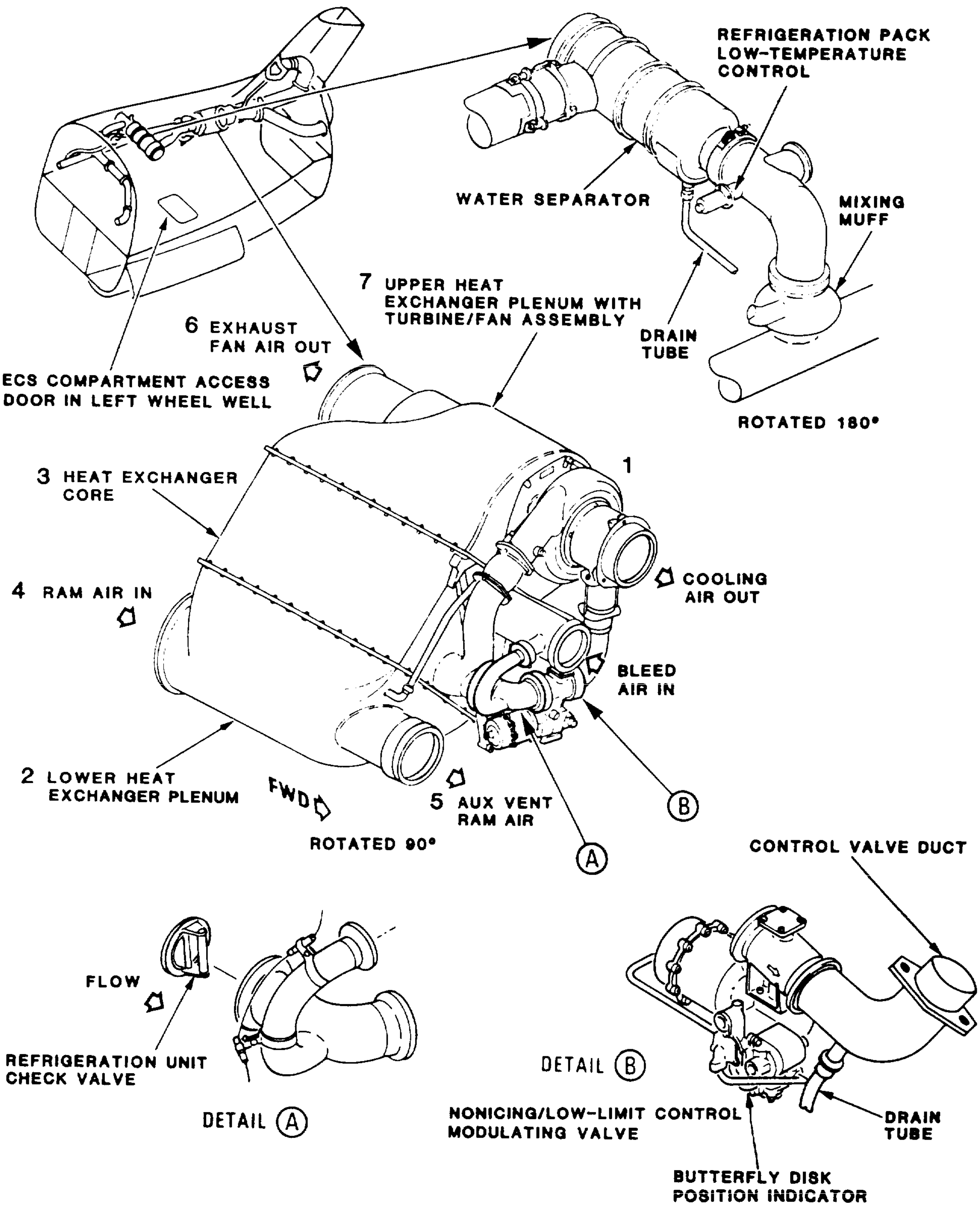

Figure 4-7.-Refrigeration package and water separator.

icing. (See figure 4-8.) Ice forming on the wire screen at the water separator discharge duct is detected by two pneumatic pickups located just before and after the water separator. These pickups sense a differential pressure across the water separator. If differential pressure is sensed across the water separator, the nonice and low-limit control valve will remain open until the temperature of the inlet air to the water separator is high enough to melt collected ice. When the ice is melted, the pressure differential returns to normal. In addition, the refrigeration pack low-limit control electrically signals the nonice and low-limit control valve when separator outflow drops to 0°F.

REFRIGERATION PACK LOW-LIMIT CONTROL.— The refrigeration pack low-limit control (fig. 4-6) is located in the ECS compartment. It is mounted downstream from the water separator in a 6-inch duct of cooled discharged bleed air.

The refrigeration pack low-limit control uses 28-volt dc power to energize its circuitry. A thermistor senses duct air temperature and compares it with an internally generated reference. The difference is amplified to modulate a torque motor in the nonice and low-limit control valve. (See figure 4-8.) The torque valve controls the regulated air supply (3) with a flapper valve (1), which controls the diaphragm pressure in a butterfly actuating linkage (12). The nonice and low-limit control valve can be returned to the differential pressure control mode by opening the cabin temperature high-limit thermostat (4). This causes the upper chamber (6) of the switcher valve (7) to be vented (17) and returned to its primary position. A check valve (5) is provided to prevent extraneous signals from affecting the nonice and low-limit control valve.

REFRIGERATION UNIT CHECK VALVE.— The refrigeration unit check valve (fig. 4-7, detail A) is an insert-type check valve with a split flapper spring-loaded in the closed position. The valve, which is installed in the refrigeration unit to prevent hot bleed air from entering directly into the turbine, is located in a tee arrangement in the system just downstream of an orifice.

Icing of the water separator will occur only at low altitudes where mass airflow and temperature are relatively high. Only a small amount of high-temperature air is required through the orifice to melt such a deposit. However, at high altitude where the mass flow and bleed-air temperatures are low, the refrigeration pack low-limit control operates to open the nonice and low-limit control valve. When the nonice and low-limit control valve is open, high differential pressure across the bleed-air orifice permits the refrigeration unit check valve to open. This allows intermediate-temperature air to bypass the turbine, and thereby maintain water separator temperature above 0°F. (See figure 4-6.)

CABIN AIR/WATER SEPARATOR, COALESCER CONE, AND COALESCER BAG.— The water separator is a welded cylindrical aluminum container installed downstream from the turbine and fan assembly. Its purpose is to remove a portion of the moisture condensed during the air-expansion process within the expansion turbine. (See figure 4-6.) The water separator container holds a coalescer bag, which collects the finely dispersed fog-like moisture discharged from the turbine. The wet air flows through the coalescer cone and through louvered swirl vanes to cause the heavier water particles to be deposited by centrifugal force against the outer surface of the collector section. Accumulated water is drained through the sump in the bottom of the collector section. The partially dried air then leaves the water separator by way of the air outlet duct. The coalescer bag may be removed for cleaning through an access cover secured with a quick-disconnect band coupling to the water separator shell.

WATER SEPARATOR ICE SCREEN.— An ice screen is located in the discharge end of the water separator to collect ice when moisturized airflow temperature is below the dew point temperature, or below 32°F. The condensed ice crystals gathered across the ice screen cause a pressure differential, which is sensed by the nonice and low-limit control valve. The nonice and low-limit control valve then increases the warm air supply through the mixing muff, the coalescer bag, and to the ice screen to melt collected ice.

WATER SEPARATOR BYPASS VALVE.— The bypass valve is a spring-loaded valve mounted in the water separator container. A failure of the nonice and low-limit control valve could cause ice particles to build up in the water separator coalescer bag. This ice would block the cabin air system. To ensure that air is supplied to the cabin, the water separator bypass valve allows turbine air to bypass the coalescer bag.

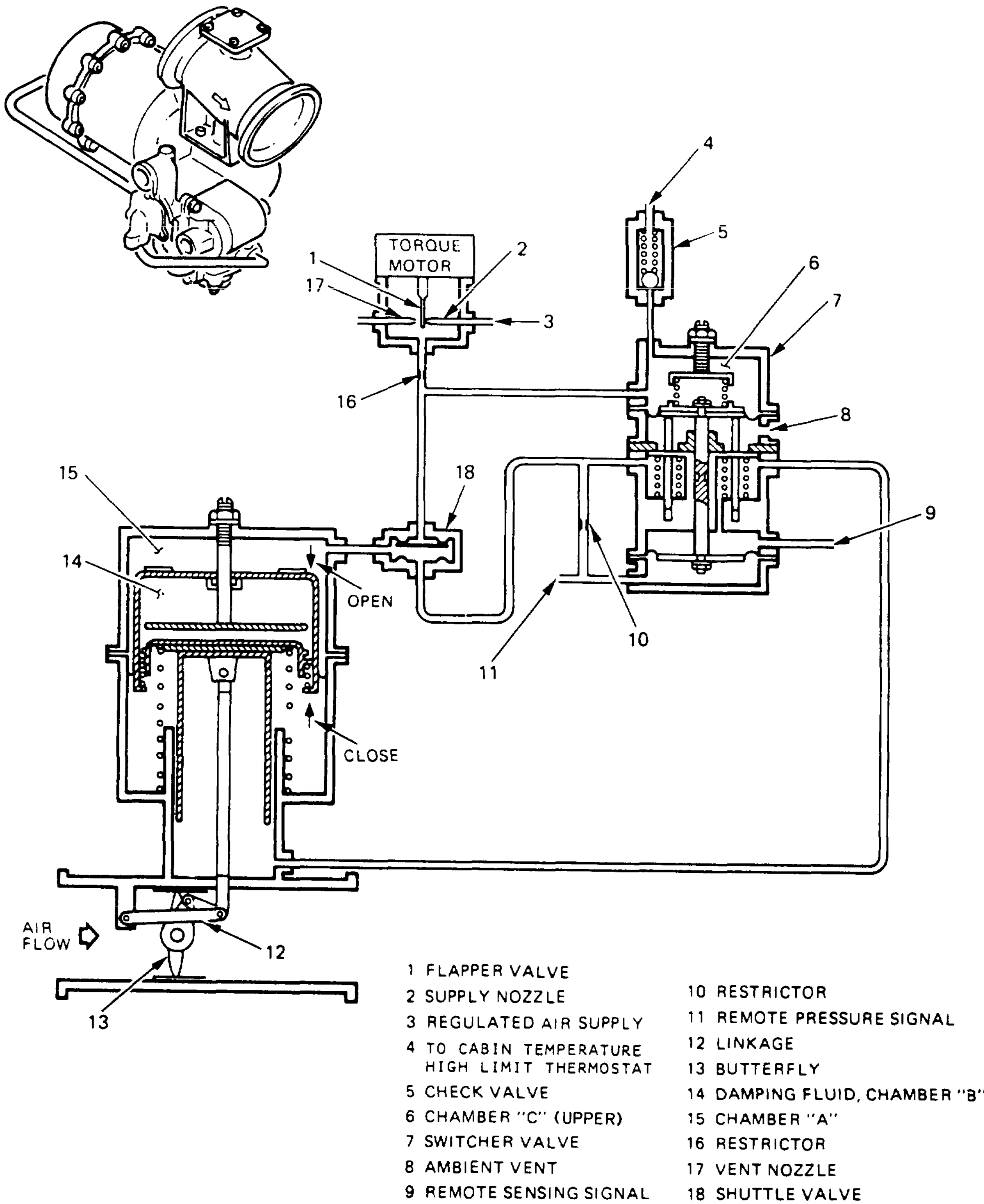

Figure 4-8.-Nonicing and low-limit control modulating valve schematic.

CABIN TEMPERATURE CONTROL SUBSYSTEM

A cabin air temperature control sensor is located mid cabin adjacent to the TACCO cooling air inlet. Its purpose is to ensure adequate airflow over the sensor, which measures cabin temperature and sends a signal, along with a signal from the cabin air temperature selector, to the cabin air temperature control. The cabin air temperature control then directs the cabin temperature control modulating valve to maintain a selected temperature in the cabin. During normal cruise, cabin air temperature is controlled by mixing water separator cold air with hot bleed air. The control also acts as an anticipator to stabilize response from the supply duct sensor to the cabin temperature demand.

System Operation

The cabin temperature control subsystem cools the bleed-air supply by air-cycle refrigeration and ram air mixing to provide a cabin temperature within the range of 60° to 80°F during steady and mild transient conditions. The cabin temperature is maintained within ±3°F of the selected value and a temperature differential of 10°F between the floor level and the head level. Humidity control ranges from a relative humidity of 5 to 70 percent. The cabin exhaust air, after passing through the internal avionics and the sonobuoy and weapons bays, is exhausted overboard.

Cabin air temperature is monitored by a sensor mounted on the aisle next to the cooling air inlet at the TACCO side console. The sensor measures the flight station air temperature and generates a signal that is transmitted to the cabin air temperature control. Additionally, a signal from the temperature select switch is sent to the control. The cabin air temperature control senses the inlet duct temperature and compares the signals to modulate the cabin temperature control valve. Based on this comparison, it allows the proper amount of hot bleed air to enter the mixing muff at the conditioned air outlet. The cabin air temperature control acts as an anticipator to stabilize the response of the supply duct air temperature to cabin temperature demands. It also minimizes cabin air supply duct temperature changes because of bleed- or ram-air temperature change. (See figure 4-9.)

In the manual mode, the automatic controls are overridden to provide manual control of the cabin temperature control valve. Since the cabin air temperature control is bypassed, the 160°±5°F limit on the cabin air temperature control is raised to 185°±15°F, as sensed by the cabin air high-temperature limit thermostat. If the pilot has selected the temperature select switch position for which this 185°±15°F is exceeded, the cabin temperature control subsystem will cycle open and closed until manual control is repositioned or conditions change to reduce maximum supply temperature.

The augmented air system provides ram air, as required, to supplement the conditioned bleed air and to provide auxiliary ventilation. This ram air is drawn from the ram-air scoop located in the base of the vertical stabilizer. The ram air is injected into the cabin air distribution ducting downstream from the mixing muff at the junction between the water separator discharge air and the cabin temperature control valve.

During unpressurized flight up to 3,500 feet (+1000 or –500 feet) with a ram air temperature between 20°±6°F and 72°±6°F, ram air supplements the conditioned bleed-air flow to the cabin. When operating in the automatic mode, the ram-air shutoff valve controls the duct-to-cabin pressure differential to 7.5 ± 2 inches of water to prevent flooding the cabin with ram air when the aircraft is flying at high speeds.

The ram-air shutoff valve is also used to provide auxiliary ventilation by securing the refrigeration package and relying on the pilot-operated auxiliary vent switch to adjust the ram-air shutoff valve. (See figure 4-10.) With the air-conditioning switch set to OFF, setting the auxiliary vent switch to ON closes the cabin recirculating air temperature control valve and opens the cabin pressure regulator valve. If the setting of the ram-air shutoff valve is such that ram pressure fails to satisfy cabin exhaust fan requirements, the negative pressure relief valve opens. This draws additional ambient air from the environmental control system compartment to compensate for any airflow deficiencies.

In the event of an automatic shutdown of the air-conditioning or pressurization system during single-engine waveoff, the cabin air supply temperature may change because the ram-air shutoff valve opens. Operation is restored by setting the air-conditioning switch to OFF/RESET and then back to ON, or by setting the auxiliary vent switch to modulate the ram airflow.

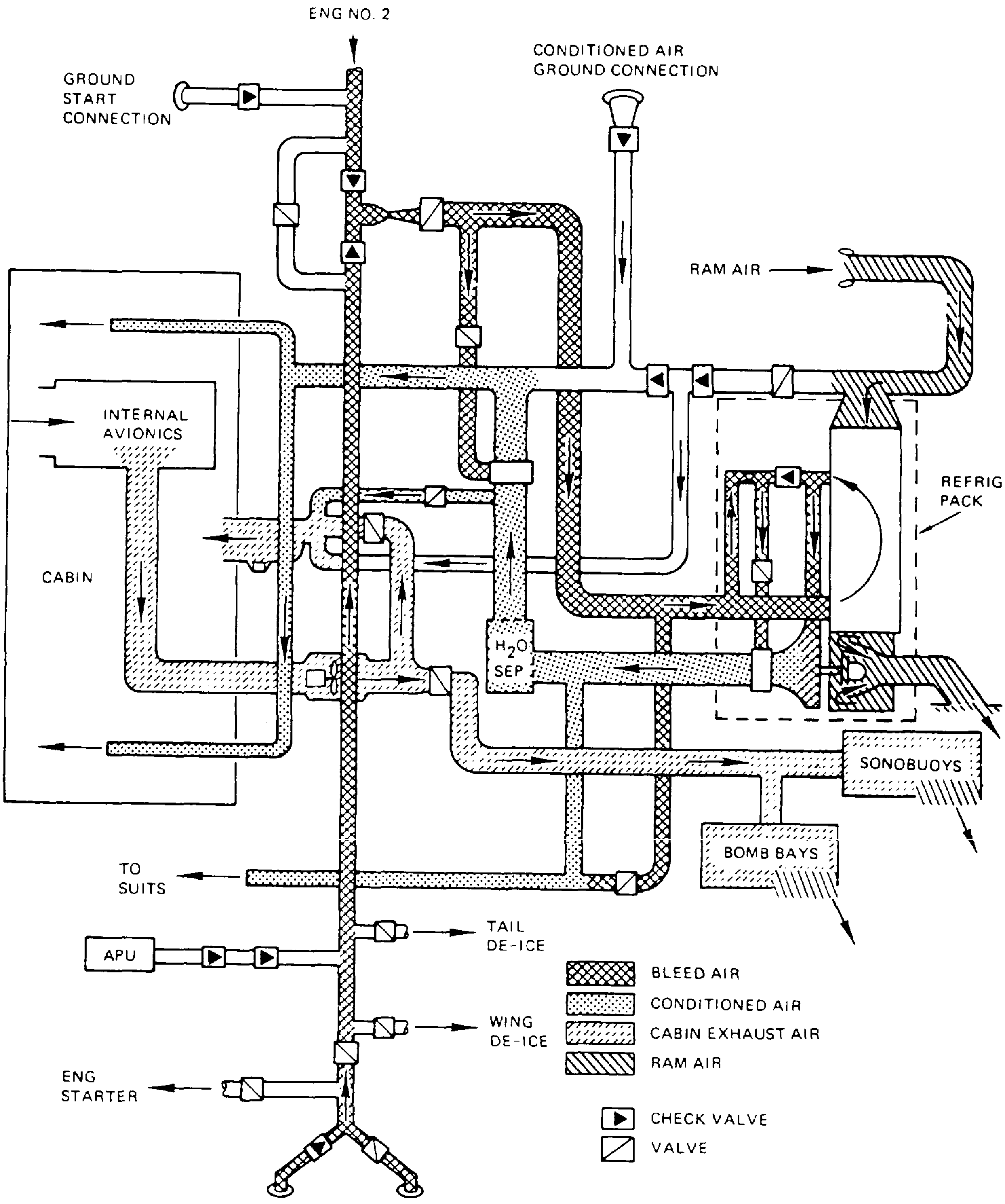

Figure 4-9.-Environmental control system operation during pressurized flight.

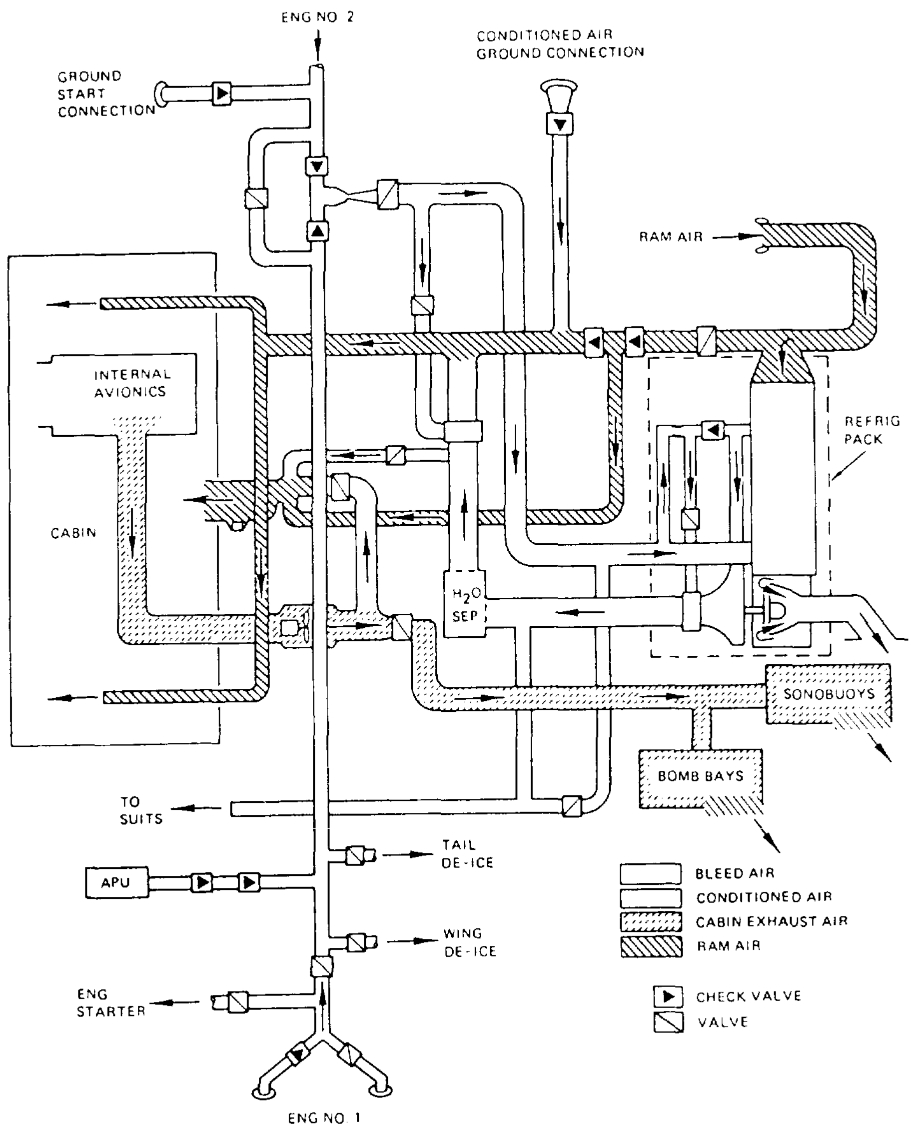

Figure 4-10.-ECS operation in aux vent mode.

System Components

Seven components are used to control cabin temperature. These components are discussed in the following paragraphs.

CABIN TEMPERATURE CONTROL MODULATING VALVE.— The cabin temperature control modulating valve has a visual position indicator and is spring-loaded to the closed position. It is located between the hot bleed-air duct going to the refrigeration unit and the cooled air duct coming from the refrigeration unit. The cabin air temperature control provides electrical power to a torque motor in the valve, which converts electrical signals into pneumatic signals that modulate the butterfly to a specific opening.

CABIN AIR TEMPERATURE CONTROL.– The cabin air temperature control, which is located in the cabin inlet duct, senses duct temperature with two thermistors and a control circuit for signal comparison. The cabin air temperature control output signal is in proportion to the sensed temperature differential between the inlet duct temperature and an input from the cabin air temperature sensor. The output of the cabin air temperature control, which goes through the cabin air temperature selector, provides a controlling signal for the cabin temperature control valve.

CABIN AIR HIGH-TEMPERATURE LIMIT THERMOSTAT.— The cabin air high-temperature limit thermostat is a pneumatic control valve that actuates as a function of cabin inlet air temperature sensed at the cabin air inlet duct. The thermostat's internal valve opens between 182° and 200°F and dumps regulated air pressure from the cabin temperature control valve and the nonice and low-limit control valve. This induces both valves to close.

The thermostat uses a temperature-sensing liquid contained in a sealed-wall probe. Vapor forms above the liquid, varies in pressure with surrounding temperature, and actuates a disc spring that dumps the air pressure supply.

CABIN AIR TEMPERATURE CONTROL SENSOR.— The cabin air temperature sensor, located mid cabin, consists of two thermistor probes in parallel that have a nominal 4,000-ohm resistance at 77°F. The sensor, which operates over a temperature range of 55° to 85°F, is connected to the cabin air temperature control, and it is designed to control cabin temperature to within ±3°F of the selected temperature.

RAM-AIR SHUTOFF VALVE.— The ram-air shutoff valve (fig. 4-11) consists of a butterfly valve (9) and linkage. It is opened by a spring and closed by an air-pressure actuated diaphragm (11). The diaphragm is activated by a regulated air

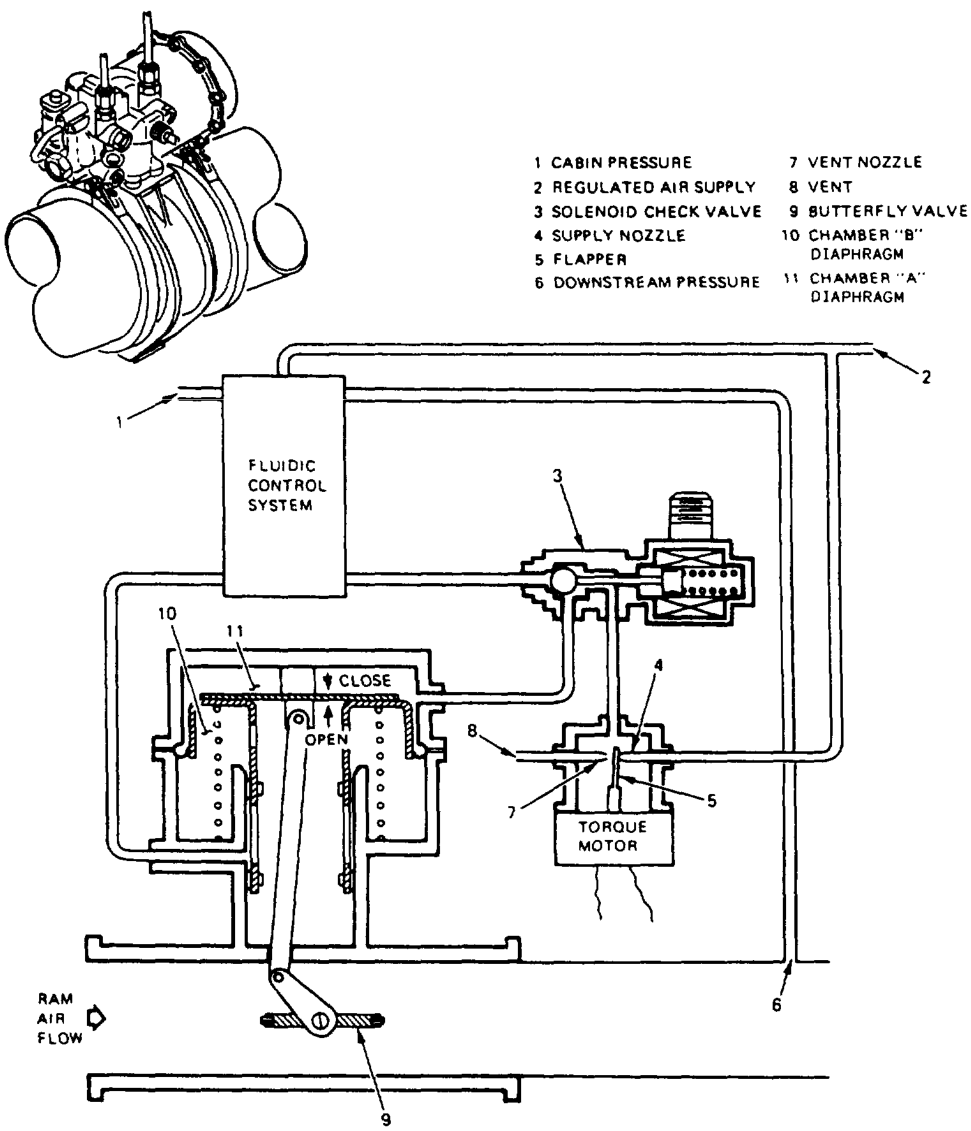

Figure 4-11.-Ram-air shutoff valve schematic.

supply that is controlled by a fluidic control system or a torque motor and flapper (5), depending upon whether the solenoid is energized or de-energized.

During the ram-air augmentation mode (automatic mode), the ram-air shutoff valve regulates downstream pressure to a fixed differential of 7.5 ± 2 inches of water above cabin pressure. The automatic mode is selected by energizing the solenoid. This allows the fluidic control to establish the differential across the valve actuator as determined by valve downstream pressure (6) and cabin pressure (1).

During manual operation (override mode), the auxiliary vent switch on the environmental panel is used to place the ram-air shutoff valve in any position from fully closed to fully open by varying electrical power to the valve torque motor. In the override mode, selected by de-energizing the solenoid, power is applied to the torque motor to close the pneumatic supply pressure nozzle and to open the vent nozzle, thereby lessening the ram-air shutoff valve actuator closing pressure. This permits the actuator spring to move the butterfly toward an open position.

RAM-AIR HIGH-AND LOW-TEMPERATURE LIMIT SWITCH.— The ram-air high- and low-temperature limit switch senses air temperature at the ram-air inlet duct. There are two circuits in the ram-air high- and low-temperature limit switch that are normally closed. One circuit opens with decreasing ram-air temperature, and the other opens with increasing ram-air temperature. The ram-air high- and low-temperature limit switch circuitry is interconnected with the bleed-air flow control valve, the ram-air shutoff valve, and the auxiliary vent switch. The ram-air high- and low-temperature limit switch operation controls the ram-air shutoff valve position when the ram-air shutoff valve is operating in the automatic mode.

GROUND AIR SUPPLY CHECK VALVE AND GROUND COOLING AIR CONNECTOR.— Support equipment provides low-pressure conditioned air when it is attached to the ground cooling air connector. The connector is located on the right side of the aircraft in the right wheel well at fuselage station (FS) 465. It is accessible through a hinged door on the underside of the sonobuoy deck. The connector consists of a silicone-impregnated nylon hose and a clamp supporting the air check valve.

The ground air check valve is a 4-inch diameter, split-flapper valve spring-loaded to the closed position. Ground cooling air opens the check valve and closes the ram and recirculated air check valves. The ground source low-pressure air bypasses the refrigeration unit and enters the cabin area because the air-conditioning system is not used when low-pressure ground air is connected. Therefore, the bleed-air flow control valve will be closed.

ENVIRONMENTAL CONTROL PANEL

The environmental control panel (fig. 4-12) is located on the center console and is used by the flight crew to control temperature, pressurization, and anti-icing functions. The discussion of this panel is limited to the ram-air valve position selector, air-conditioning switch, and the cabin air temperature selector.

Ram-Air Valve Position Selector

When the ram-air valve position selector (AUX VENT switch) is placed in the OFF position, the automatic mode is established by way of the fluidic control system. Clockwise rotation towards the ON position overrides logic controls of the air-conditioning system. Control of the ram-air shutoff valve is determined by the

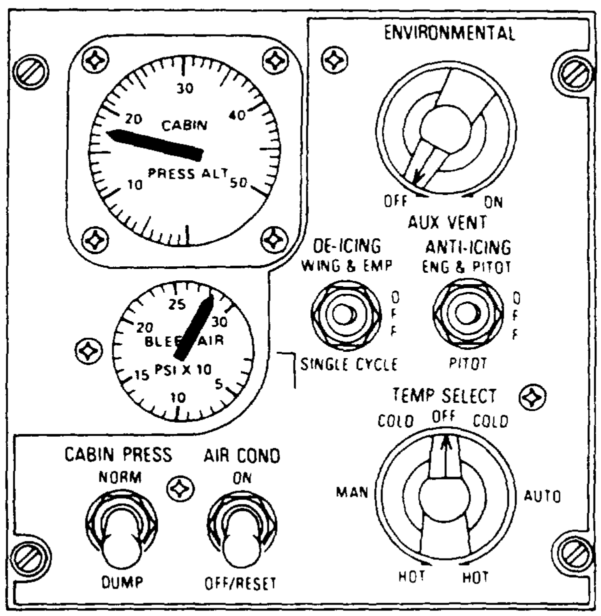

Figure 4-12.-Environmental control panel.

magnitude of the current, which is proportional to the setting of the auxiliary vent switch.

Air-Conditioning Switch

The air-conditioning switch (AIR COND switch) is used to activate the air-conditioning system. When air conditioning is automatically shutdown and the ram-air shutoff valve has fully opened, the air-conditioning switch must be set to OFF/RESET, and then back to ON to restore normal operation.

Cabin Air Temperature Selector

The cabin air temperature selector (TEM SELECT switch) has a manual and an automatic mode of operation. The temperature select switch operates manually in the same manner as the auxiliary vent switch. In the automatic mode, cabin temperature is selectable from 60° to 80°F.